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(54) PLATING METHOD FOR PERMANENT MAGNET

(57)Abstract:
PROBLEM TO BE SOLVED: To efficiently obtain a permanent magnet with a plating layer excellent in dimensional precision and corrosion resistance is formed by immersing the permanent magnet to be treated into an electropolishing soln. of specified pH value, executing energizing, subjecting the surface of the magnet to electropolishing and thereafter executing electroplating.
SOLUTION: For example, a magnet stock of rectangularly parallelepipedic body as it is after compacting and sintering or in which required machining has been completed is immersed into an electrolytic grinding soln., which is energized for required time to subject the surface of the permanent magnet to electropolishing by required depth particularly with the edge part as the center, and, after that, plating is executed. As a result, the electric current concentrates on the edge of the object to be treated, and, therefore, the plating layer is thickly formed on the edge of the magnetic stock of the rectangular parallelepipedic body. The electropolishing soln., is required to be neutral or alkaline with pH of 6.0 which does not dissolve the magnet only by immersion to control the amount of polishing with energizing time. As for the magnet to be treated, both sintered magnets and bond magnets are made the object, but, there is remarkable effect on R-Fe-B permanent magnets in particular.

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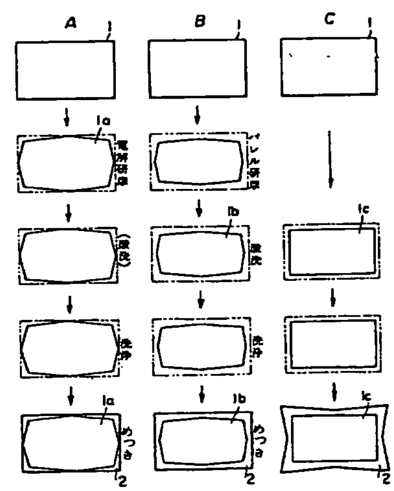
(54)【発明の名称】永久磁石のめっき方法

(57)【要約】

【課題】　電気めっき法による耐食被膜の形成に際し、磁石表面の平行度、平面度及び輪郭度などの寸法精度に優れ、かつ優れた耐食性を有するめっき層を形成した永久磁石を、省工程や連続処理を可能にして、効率よく大量生産できる永久磁石のめっき方法の提供。

【解決手段】　浸漬のみでは磁石を溶解することがない電解研摩液を用いて、所要の電流密度で通電時間を制御することにより、電解研摩による研摩量を正確に制御でき、磁石端部を優先的に研摩することにより、めっき処理後のめっき膜厚が不均一となって寸法精度が低下するのを抑制でき、省工程や連続処理が可能となる。



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【特許請求の範囲】

【請求項1】　永久磁石をｐＨ６．０以上の電解研摩液中に浸漬し、通電して永久磁石表面を陽極電解研摩した後、電気めっきを施す永久磁石のめっき方法。

【請求項2】　請求項1において、陽極電解研摩工程、酸洗及び／又は洗浄工程、電気めっき工程を連続して行なう永久磁石のめっき方法。

【請求項3】　請求項1または請求項2において、永久磁石がＲ－Ｆｅ－Ｂ系焼結磁石またはＲ－Ｆｅ－Ｂ系ボンド磁石である永久磁石のめっき方法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】この発明は、Ｒ－Ｆｅ－Ｂ系磁石などの永久磁石のめっき方法の改良に係り、めっき処理の前工程として、ｐＨ６．０以上の電解研摩液を用いて該磁石に陽極電解研摩を施し、磁石端部を優先的に研摩することにより、めっき処理後のめっき膜厚が不均一となって寸法精度が低下するのを抑制でき、省工程や連続処理が可能な永久磁石のめっき方法に関する。

【０００２】

【従来の技術】従来、高性能永久磁石、特にＲ－Ｆｅ－Ｂ系永久磁石（ＲはＹを含む希土類元素の少なくとも１種）は耐食性向上のために保護被膜を設ける必要があり、その表面処理方法としては、電気めっき法、無電解めっき法、樹脂塗装法、アルミクロメート処理法などが知られている。

【０００３】特に、電気めっき法は、得られる被膜が緻密で優れた耐食性を有し、大量生産に適していることから、当該Ｒ－Ｆｅ－Ｂ系磁石の表面処理の主流となっている。しかしながら、電気めっき法においては、電流密度が被処理物の端部に集中するため、被処理物の中央部よりも端部の膜厚が厚くなる、いわゆるドッグボーン現象が避けられない。

【０００４】上記のドッグボーン現象は、めっき厚が厚くなる程著しく、被処理物の中央部と端部との寸法差は拡大することとなり、被処理物の平行度、平面度及び輪郭度などの寸法精度が低下する。

【０００５】現在、Ｒ－Ｆｅ－Ｂ系永久磁石は、その高性能を生かすべく小型精密機器、コンピュータ機器、オーディオ機器などに多用されており、必然的に小型・軽量化とともに高い寸法精度が要求され、かつ高耐食性を有することが不可欠とされている。

【０００６】Ｒ－Ｆｅ－Ｂ系永久磁石の耐食性を考慮すると、めっき厚みは、一般に１０～３０μｍ程度必要となるが、上述の如く、厚みを増すにつれドッグボーンが大きくなるため、より寸法精度が低下することになる。従って、従来は、めっき処理前にバレル研摩などを施し、予め磁石素材の端部にＲ面取りを行なって、めっき処理後の膜厚を均一化する方法が採られていた。

【０００７】

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【発明が解決しようとする課題】詳述すると、図１Ｃに示す如く、例えば、直方体や円柱の磁石素材１（図１Ｃにおいては、直方体の断面を示す）をその表面の焼結及び加工変質層を除去するために酸洗処理した後、めっき処理すると、電流が被処理物の端部に集中するため、めっき層２は直方体の磁石素材１端部に厚く成膜される。

【０００８】そこで、従来のめっき液に替えて、均一膜厚性の優れためっき液を用いることも行なわれているが、完全にドッグボーンを抑制することはできない。これは、電気めっき法である限り、避けることができない。

【０００９】また、めっき処理後の膜厚を均一化するため、上記のめっき処理前にバレル研摩を行なう場合、図１Ｂに示す如く、磁石素材１をバレル研摩した後、酸洗し、めっき処理するが、バレル研摩による面取り工程に多大の時間と手間を要するため、生産能率の低下及びコストアップを招き、また、端部のみならず平面部を含む全体が研摩されるため、加工ロスが問題となっていた。

【００１０】また、電気めっき法に代えて無電解めっき法を採用するなどの方法も試みられているが、めっき液のコスト高とともに、電気めっき法に比べめっき液の管理が難しいという問題があった。

【００１１】この発明は、従来の電気めっき法の問題を解決し、磁石表面の平行度、平面度及び輪郭度などの寸法精度に優れ、かつ優れた耐食性を有するめっき層を形成した永久磁石を、省工程や連続処理を可能にして、効率よく大量生産できる永久磁石のめっき方法の提供を目的とする。

【００１２】

【発明を解決するための手段】発明者らは、従来行なわれていた、めっき処理の前工程としてバレル研摩を行ない、磁石端部を優先的に研摩してドッグボーン現象により生じる端部の余剰な厚み分を予め除去することにより、電気めっき後の磁石の寸法精度を向上させる方法において、より工程を削減し、効率の良い連続処理を実現できる方法を目的に種々検討を行ない、特に電解研摩に着目して鋭意研究した結果、浸漬のみでは磁石を溶解することがない電解研摩液を用いて、所要の電流密度で通電時間を制御することにより、電解研摩による研摩量を正確に制御でき、電気めっき後の磁石の寸法精度を高度に調整できることを知見した。

【００１３】さらに、発明者らは、電解研摩工程と電気めっき工程とを、処理槽を並べた同一ラインで連続的に行なうことが可能であり、省工程化と連続処理により生産能力の向上を図ることができ、磁石表面の平行度、平面度及び輪郭度などの寸法精度に優れ、かつ優れた耐食性を有するめっき層を形成したＲ－Ｆｅ－Ｂ系磁石等の永久磁石を安定的に製造できることを知見し、この発明を完成した。

【００１４】すなわち、この発明は、浸漬のみでは磁石

を溶解することがない、pH6．０以上の電解研摩液中に被処理永久磁石を浸漬し、通電して永久磁石表面を所要深さだけ電解研摩した後、後工程で所要の電気めっきを行なうことを特徴とする永久磁石のめっき方法である。

【００１５】また、発明者らは、上記構成のめっき方法において、電解研摩工程、酸洗及び／又は洗浄工程、電気めっき工程を連続して行なう方法、被処理永久磁石がＲ－Ｆｅ－Ｂ系焼結磁石またはＲ－Ｆｅ－Ｂ系ボンド磁石である方法を併せて提案する。

【００１６】

【発明の実施の形態】この発明の工程の一例は、図１Ａに示す如く、成形や焼結後そのままあるいは所要の機械加工を完了した、例えば直方体の磁石素材１を電解研摩液中に浸漬し、所要時間通電して永久磁石表面、特に端部を中心に所要深さだけ電解研摩した後めっき処理すると、電流が被処理物の端部に集中するため、めっき層２は直方体の磁石素材１の端部に厚く成膜される。

【００１７】詳述すると、この発明は、めっきとは全く逆の陽極電解研摩により、被処理永久磁石素材の端部を優先的に研摩するもので、研摩量を次工程のめっき時に当該位置に付着するめっき層厚み分と等しくすることにより、めっき処理後に成膜されためっき層厚みの中央部と端部との差が、めっき磁石表面に寸法差として現われず、磁石表面の平行度、平面度及び輪郭度などの寸法精度が極めて優れているという効果を奏する。

【００１８】また、この発明においては、電解研摩による研摩量を正確に制御することができるため、寸法精度を高度に調整可能で、さらに、次工程の酸洗処理を省略又は軽度な処理とすることができ、省工程、処理時間の短縮などを図ることも可能となる。

【００１９】この発明において、被処理永久磁石としては、公知のいずれの組成の焼結磁石、ボンド磁石も対象とすることができ、磁石形状も直方体、立方体、円筒状、リング状などいずれの形状であっても同様であり、特に、耐食性保護被膜が必須であるＲ－Ｆｅ－Ｂ系永久磁石に対して顕著な効果を奏する。

【００２０】この発明において、電解研摩液は、通電時間などで研摩量を制御するため、浸漬のみでは磁石を溶解させることがない、pH6．０以上の中性あるいはアルカリ性であることが必要であり、さらには、液中に含有する塩類も浸漬時の被処理永久磁石を極力溶解することがないものが好ましい。

【００２１】特に、Ｒ－Ｆｅ－Ｂ系永久磁石の場合、電解研摩液としては、前記の通り、pH6．０以上の中性あるいはアルカリ性からなり、電気伝導塩類として、硫酸ナトリウム、塩化ナトリウム、硫酸カリウム、塩化カリウム等、錯化剤として、ＥＤＴＡ（エチレンジアミンテトラ酢酸）、ピロリン酸等、界面活性剤としてラウリル硫酸Ｎａ、アルキルベンゼンスルホン酸Ｎａ等を含む組成を有するものが好ましい。

【００２２】また、陽極電解研摩の条件は、用いる電解研摩液や永久磁石の種類により異なるが、特に、Ｒ－Ｆｅ－Ｂ系永久磁石の場合、研摩量を通電時間で制御するためには、処理槽として、塩化ビニール、ゴムライニング、ＰＰ槽等、電極として、ステンレス鋼等の不溶性電極等を用いて、液温２０～５０℃、電流密度０．１～１０Ａ／dm²、電気伝導度１００～３００mS／cmの条件で行なうことが好ましく、さらに好ましくは、液温３０～４０℃、電流密度１～５Ａ／dm²、電気伝導度１５０～２００mS／cmである。

【００２３】この発明の工程の一例を示す図１Ａでは、磁石素材を陽極電解研摩し、酸洗処理後、電気めっきしているが、酸洗処理工程は省略又は軽度な処理とすることができ、また、必要に応じて活性化処理等を適宜加えることもでき、いずれの場合も処理槽に浸漬するため、バレル研摩の如き機械加工で別ラインを通ることなく、陽極電解研摩からめっき処理まで連続ライン処理が可能である。

【００２４】

【実施例】実施例１

寸法が３０mm×１５mm×２mmからなる直方体のＲ－Ｆｅ－Ｂ系焼結磁石を被処理磁石素材１として、硫酸ナトリウム、ＥＤＴＡを主成分として含有する温度４０℃の電解研摩液（商品名パクナ、ユケン工業社製、pH＝７．０）に浸漬し、電流密度１．０Ａ／dm²で１５分間通電し、陽極電解研摩処理を施したところ、中央部が２μm、端部が１２μm深さで表層が電解研摩された磁石素材１ａを得た。

【００２５】この磁石素材１ａを水洗浄後に、電気めっき法によりＮｉを被覆したところ、磁石素材１ａの中央部には１５μm、端部には２５μm厚みのＮｉめっき層２が形成され、中央部と端部との平面度の交差は０μmであった。

【００２６】比較例１

実施例１と同じ被処理磁石素材１に、バレル研摩を４時間施したところ、中央部が１０μm、端部が２０μm深さで研摩された磁石素材１ｂを得た。該磁石素材１ｂに短時間の酸洗処理を施し、次いで実施例１と同条件で電気めっき法によりＮｉを被覆したところ、磁石素材１ｃの中央部には１５μm、端部には２５μm厚みのＮｉめっき層２が形成され、中央部と端部との平面度の交差は０μmであった。

【００２７】比較例２

実施例１と同じ被処理磁石素材１を、酸洗処理して表層１０μmをエッチングし、該磁石素材１ｃに実施例１と同条件で電気めっき法によりＮｉを被覆したところ、磁石素材１ｃの中央部には１５μm、端部には２５μm厚みのＮｉめっき層２が形成され、端部のＮｉめっき層は中央部より１０μm厚く成膜されていた。

【0028】実施例1から明らかなように、この発明による、陽極電解研摩を施した後、電気めっきする方法によれば、中央部と端部との交差は0μmであり、優れた平面度が得られ、また、端部のみを優先的に研摩できるため、中央部の研摩量はごく僅か（2μm）であることが分かる。

【0029】一方、バレル研摩を施した後、電気めっきする方法（比較例1）によれば、平面度はこの発明の実施例と同様に優れているが、バレル研摩工程に多くの時間を要するとともに、端部のみならず中央部も研摩されるため、研摩に伴うロスが大きいことが分かる。さらに、予め端部を研摩しない方法（比較例2）によれば、中央部よりも端部に厚く成膜されるドッグボーン現象が生じていることが分かる。

【0030】実施例2
外径40mm、内径20mm、厚み1mmからなる偏平リング状のR－Fe－B系焼結磁石を被処理磁石素材として、実施例1と同じ電解研摩液を用い、温度20℃の該電解研摩液中に被処理磁石素材を浸漬し、電流密度0．6A／dm^{2}で20分間通電し、陽極電解研摩処理を施した。なお、研摩時の電気伝導度は250mS／cmであった。

【0031】得られた磁石素材は、リング外周面中央部が1μm、リング外周面端部が15μm深さで表層が電解研摩されていた。次いで、該磁石素材を水洗浄後に、電気めっき法によりNiを被覆したところ、リング外周面中央部には15μm、リング外周面端部には29μm厚みのNiめっき層2が形成され、中央部と端部との平面度の交差は0μmであった。

【0032】実施例3
外径20mm、内径17mm、厚み30mmからなる円筒状のR－Fe－B系ボンド磁石を被処理磁石素材として、実施例1と同じ電解研摩液を用い、温度40℃の該電解研摩液中に被処理磁石素材を浸漬し、電流密度2．0A／dm^{2}で5分間通電し、陽極電解研摩処理を施した。なお、研摩時の電気伝導度は150mS／cmであった。得られた磁石素材は、リング外周面中央部が0．5μm、リング外周面端部が10．5μm深さで電解研摩されていた。

【0033】次いで、該磁石素材を空孔処理後、実施例3と同じ条件で電気めっき法によりNiを被覆したところ、リング外周面中央部には11μm、リング外周面端部には21μm厚みのNiめっき層2が形成され、中央部と端部との平面度の交差は0μmであった。

【0034】実施例1～実施例3から明らかなように、焼結磁石、ボンド磁石問わず、優れた平面度を得ることが可能であり、また、その形状がいかなる場合でも同様の効果が得られることが分かる。なお、上記実施例においては、好ましい実施形態としてR－Fe－B系永久磁石をとりあげたが、電気めっきを行なうことができる永久磁石材料であれば、上記と同じ効果を得ることが可能である。

【0035】実施例4
電流密度1．5A／dm^{2}で20分間通電する以外は、実施例1と同じ磁石素材、同じ方法で、陽極電解研摩処理、Niめっきを施した。磁石素材時、陽極電解研摩処理後、Niめっき後の各々の厚み寸法の分布を図2に示す。比較として、比較例2における、磁石素材時、酸洗処理後、Niめっき後の各々の厚み寸法の分布を図3に示す。なお、縦軸は分布割合（%）を示す。

【0036】図2から明らかなように、この発明によれば、電解研摩後の分布において、中央部と端部とが完全に分れ二山を形成している。これは、電解研摩によって端部のみが研摩されたことを示す。また、Niめっき後の分布は、中央部と端部はほぼ重なっており、平面度が良好であることが分かる。

【0037】一方、図3に示す、陽極電解研摩処理を行なわない比較例の方法においては、酸洗処理後の分布は、中央部と端部はほぼ重なっているが、Niめっき後の分布は、中央部と端部とが完全に分れ、二山を形成している。これは、ドッグボーン現象によって、端部の膜厚が厚くなったことを裏付けている。

【0038】実施例5
実施例4で得たNiめっき層を有するR－Fe－B系焼結磁石の平面度、平行度、輪郭度を測定した。平面度、平行度の測定結果を図4に、輪郭度の測定結果を図5に示す。なお、比較として、比較例2で得たNiめっき層を有するR－Fe－B系焼結磁石、並びに参考として、電流密度1．0A／dm^{2}で30分間通電処理した例を合わせて図4及び図5に示す。輪郭度は姿ゲージを用いて測定を行なった。

【0039】図4から明らかなように、平面度、平行度共に、電解研摩処理を行なわない比較例に比べ良好な値を示し、また、図5に示す輪郭度についても、比較例では、素材とNiめっき後の輪郭が多少変化するが、この発明によれば、素材とNiめっき後の輪郭はほとんど変化することがないことが分かる。

【0040】図5は、この発明よるめっき方法によって得られた永久磁石の輪郭度を示すグラフであり、Aは電解研摩のない比較例の場合、Bば電解研摩（電流密度1．0A／dm^2）後の場合、Cは電解研摩（電流密度1．5A／dm^2）後の場合である。いずれも素材時の標準公差が±0．3mm以内（0．6mmで表示）の表面の輪郭の変化を電解研摩後とNiめっき後の場合を示してる。

【0041】30mm×15mm×Hmm（Hは6．5mm、4．0mm、2．8mm）寸法からなるR－Fe－B系焼結磁石を被処理磁石素材として、実施例1と同じ温度40℃の電解研摩液中に該磁石素材を浸漬し、電流密度1．0A／dm^{2}で10～30分間通電し、電解

研摩処理を施した後、電気めっき法によりＮｉを被覆したＲ－Ｆｅ－Ｂ系焼結磁石について、磁気特性（保磁力）を測定した。その結果を図６に示す。また、３０分間の電解研摩処理を施したものについて、耐食性（ＰＣＴ）試験を測定した。その結果を図７に示す。

【００４２】図６から明らかなように、この発明により得られた永久磁石は、磁石素材の厚み、電解研摩処理時間にかかわらず、良好な磁気特性を有し、また、図７から明らかなように、電解研摩処理によっても耐食性は劣化しないことが分かる。

【００４３】

【発明の効果】実施例から明らかなように、この発明によれば、陽極電解研摩により、磁石端部を優先的に研摩することができるため、めっき処理後に成膜されためっき層厚みの中央部と端部との差（ドッグボーン現象）が、めっき磁石表面に寸法差として現われず、平行度、平面度及び輪郭度などの寸法精度に優れ、かつ優れた耐食性を有するめっき層を形成したＲ－Ｆｅ－Ｂ系磁石等の永久磁石を安定的に提供することできる。

【００４４】また、この発明方法は、電流密度や通電時間などにより陽極電解研摩による研摩量を正確に制御することができるため、電気めっき後の永久磁石の寸法精度を高度に調整することができる。さらに、陽極電解研摩工程と電気めっき工程とを、処理槽を並べた同一ラインで連続的に行なうことが可能であり、また、陽極電解研摩処理後の酸洗処理を省略又は軽度な処理とすることもでき、省工程化、処理時間の短縮並びに連続処理による生産能力の向上が図れるとともに、大量生産が可能となる。

【図面の簡単な説明】

【図１】永久磁石のめっき方法の工程を示す磁石素材の断面説明図であり、Ａはこの発明方法、Ｂ、Ｃは従来方法を示す。

【図２】この発明よるめっき方法の工程毎における被処理物の厚み寸法の分布を示すグラフであり、Ａは素材の場合、Ｂは電解研摩後の場合、ＣはＮｉ電気めっき後の場合である。

【図３】従来のめっき方法の工程毎における被処理物の厚み寸法の分布を示すグラフであり、Ａは素材の場合、Ｂは電解研摩後の場合、ＣはＮｉ電気めっき後の場合である。

【図４】Ａ、Ｂはこの発明よるめっき方法によって得られた永久磁石の平面度、平行度を示すグラフである。

【図５】この発明よるめっき方法によって得られた永久磁石の輪郭度を示すグラフであり、Ａは電解研摩のない比較例の場合、Ｂは電解研摩（電流密度１．０Ａ／ｄｍ^{2}）後の場合、Ｃは電解研摩（電流密度１．５Ａ／ｄｍ^{2}）後の場合である。いずれも素材時の標準公差が±０．３ｍｍ以内（０．６ｍｍで表示）の表面の輪郭の変化を電解研摩後とＮｉめっき後の場合を示してる。

【図６】この発明よるめっき方法によって得られた永久磁石の処理時間と磁気特性（保磁力）との関係を示すグラフである。

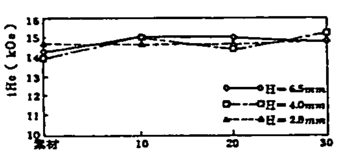
【図７】この発明よるめっき方法によって得られた永久磁石の処理時間と耐食性（ＰＣＴ）との関係を示すグラフである。

【符号の説明】

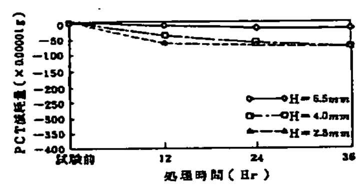
１，１ａ，１ｂ，１ｃ　磁石素材

２　めっき層

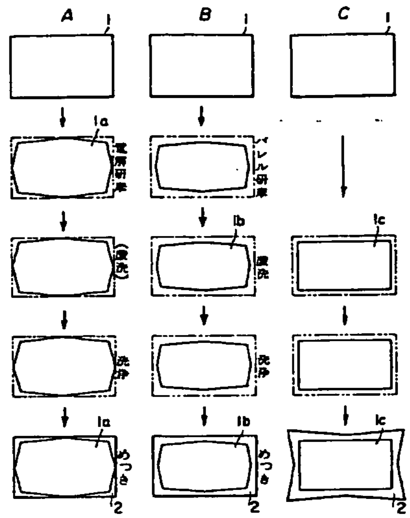
【図６】



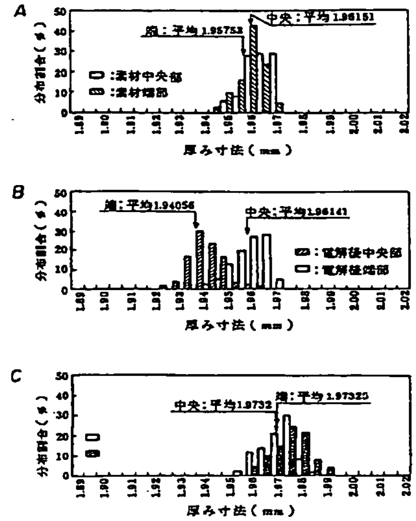
【図７】



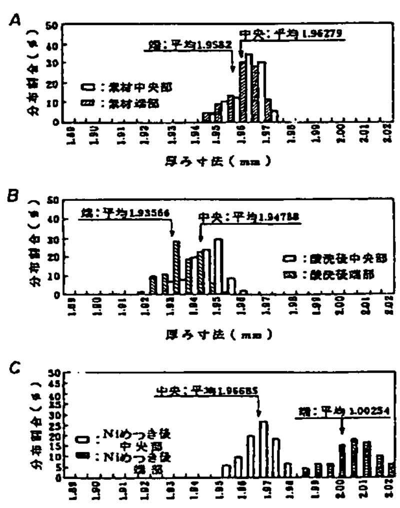
【図1】


A
B
C
電解研摩
バレル研摩
酸洗
洗浄
めっき

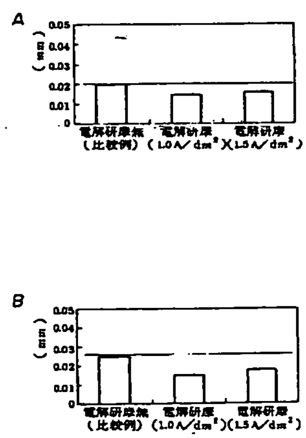
【図2】


A
中央：平均1.96151
端：平均1.95752
：素材中央部
：素材端部
B
端：平均1.94056
中央：平均1.96141
：電解後中央部
：電解後端部
C
中央：平均1.9732
端：平均1.97320
分布割合（%）
厚み寸法（mm）

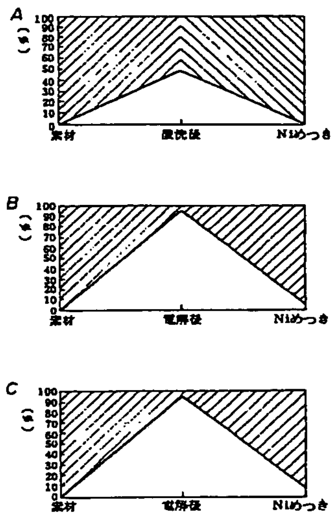
【図3】


A
端：平均1.9582
中央：平均1.96279
：素材中央部
：素材端部
B
端：平均1.93566
中央：平均1.94758
：酸洗後中央部
：酸洗後端部
C
中央：平均1.96685
端：平均1.00254
：Niめっき後中央部
：Niめっき後端部
分布割合（%）
厚み寸法（mm）

【図4】


A
B
（mm）
電解研摩無（比較例）
電解研摩（1.0A／dm²）
電解研摩（1.5A／dm²）

【図5】



CLAIMS

[Claim(s)]
[Claim 1] The plating approach of a permanent magnet of giving electroplating after being immersed into with a pH of 6.0 or more electropolishing liquid, energizing a permanent magnet and carrying out anode plate electrolytic polishing of the permanent magnet front face.
[Claim 2] The plating approach of a permanent magnet of performing an anode plate electropolishing process, acid washing and/or a washing process, and an electroplating process continuously in claim 1.
[Claim 3] The plating approach of a permanent magnet that a permanent magnet is a R-Fe-B system sintered magnet or a R-Fe-B system bond magnet in claim 1 or claim 2.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] By starting amelioration of the plating approach of permanent magnets, such as a R-Fe-B system magnet, giving anode plate electropolishing to this magnet, using with a pH of 6.0 or more electropolishing liquid as a last process of plating processing, and polishing a magnet edge preferentially, this invention can control that the plating thickness after plating processing serves as an ununiformity, and dimensional accuracy falls, and relates to the plating approach of the permanent magnet in which process saving and consecutive processing are possible.
[0002]
[Description of the Prior Art] Conventionally, a high performance permanent magnet, especially a R-Fe-B system permanent magnet (at least one sort of the rare earth elements in which R contains Y) need to prepare a protective coating for corrosion-resistant improvement, and electroplating, the nonelectrolytic plating method, the resin painting method, the aluminum chromate treatment method, etc. are learned as the surface treatment approach.
[0003] Since the coat obtained has the corrosion resistance which was precise and was excellent and fits mass production method, the surface treatment of the R-Fe-B system magnet concerned of especially electroplating is in use. However, in electroplating, in order that current density may concentrate on the edge of a processed material, the so-called dog bone phenomenon in which the thickness of an edge becomes thick rather than the center section of the processed material is not avoided.
[0004] The above-mentioned dog bone phenomenon is so remarkable that plating thickness becomes thick, the variation of tolerance of a center section and the edge of a processed material will be expanded, and dimensional accuracy, such as whenever [parallelism / of a processed material /, flatness, and profile], falls.
[0005] It is made indispensable to use current and a R-Fe-B system permanent magnet abundantly at a small precision-mechanical-equipment and computer machine, audio equipment, etc. so that they may employ the high performance efficiently, to require close dimensional accuracy with small and lightweight-ization inevitably, and to have high corrosion resistance.
[0006] Since a dog bone will become large as thickness is increased like **** although about 10-30 micrometers of plating thickness are generally needed if the corrosion resistance of a R-Fe-B system permanent magnet is taken into consideration, dimensional accuracy will fall more. Therefore, barrel finishing etc. was conventionally performed before plating processing, R beveling was beforehand performed at the edge of a magnet material, and the approach of equalizing the thickness after plating processing was taken.
[0007]
[Problem(s) to be Solved by the Invention] In order that a current may concentrate on the edge of a processed material if plating processing is carried out after carrying out acid-washing processing of the magnet material 1 (the cross section of a rectangular parallelepiped is shown in drawing 1 C) of a rectangular parallelepiped or a cylinder in order to remove sintering and the damaged layer of the front face as shown in drawing 1 C for example, if it explains in full detail, the plating layer 2 is thickly formed by magnet material 1 edge of a rectangular parallelepiped.
[0008] Then, although changing to conventional plating liquid and using the plating liquid which

was excellent in homogeneous membrane thickness nature is also performed, a dog bone cannot be controlled completely. This is unavoidable as long as it is electroplating.
[0009] Moreover, although acid washing is carried out and plating processing is carried out [in order to equalize the thickness after plating processing] after carrying out barrel finishing of the magnet material 1 as shown in drawing 1 R>1B when performing barrel finishing before the above-mentioned plating processing Since the whole which causes a fall and cost rise of production efficiency, and contains not only an edge but the flat-surface section in order for the beveling process by barrel finishing to take great time amount and time and effort was polished, the processing loss had become a problem.
[0010] Moreover, although the approach of replacing with electroplating and adopting a nonelectrolytic plating method was also tried, there was a problem that management of plating liquid was difficult compared with electroplating, with the cost quantity of plating liquid.
[0011] This invention solves the problem of the conventional electroplating, makes process saving and consecutive processing possible for the permanent magnet in which the plating layer which has the corrosion resistance which excelled and was excellent in dimensional accuracy, such as whenever [parallelism / on the front face of a magnet /, flatness, and profile], was formed, and aims at offer of the plating approach of the permanent magnet which can be mass-produced efficiently.
[0012]
[The means for solving invention] By removing beforehand a part for surplus edge [which artificers perform barrel finishing as a last process of the plating processing currently performed conventionally, polishes a magnet edge preferentially, and is produced according to a dog bone phenomenon] thickness In the approach of raising the dimensional accuracy of the magnet after electroplating, processes are reduced more. By controlling the resistance welding time only by immersion with necessary current density using the electropolishing liquid which does not dissolve a magnet, as a result of examining many things for the purpose of the approach efficient consecutive processing is realizable and inquiring wholeheartedly especially paying attention to electropolishing The amount of polishing by electropolishing could be controlled correctly, and the knowledge of the ability to adjust the dimensional accuracy of the magnet after electroplating to altitude was carried out.
[0013] Furthermore, artificers can perform an electropolishing process and an electroplating process continuously in the same Rhine which put the processing tub in order. Improvement in production capacity could be aimed at by process saving and consecutive processing, the knowledge of the ability to manufacture stably permanent magnets, such as a R-Fe-B system magnet in which the plating layer which has the corrosion resistance which excelled and was excellent in dimensional accuracy, such as whenever [parallelism / on the front face of a magnet /, flatness, and profile], was formed, was carried out, and this invention was completed.
[0014] That is, this invention is the plating approach of the permanent magnet characterized by performing electroplating necessary at a back process, after being immersed, energizing a processed permanent magnet in the with a pH of 6.0 or more electropolishing liquid which does not dissolve a magnet only by immersion and only the necessary depth's electropolishing a permanent magnet front face.
[0015] Moreover, artificers propose collectively the approach of performing an electropolishing process, acid washing and/or a washing process, and an electroplating process continuously, and how a processed permanent magnet is a R-Fe-B system sintered magnet or a R-Fe-B system bond magnet in the plating approach of the above-mentioned configuration.
[0016]
[Embodiment of the Invention] If plating processing is carried out after immersing the magnet material 1 of a rectangular parallelepiped into electropolishing liquid, carrying out duration energization and electropolishing only the necessary depth centering on a permanent magnet front face, especially an edge, for example, it completed machining remaining as it is or necessary after shaping or sintering, as an example of the process of this invention was shown in drawing 1 A, in order that a current may concentrate on the edge of a processed material, the plating layer 2 is thick at the edge of the magnet material 1 of a rectangular parallelepiped, and membranes are formed.
[0017] When it explains in full detail, this invention is what polishes the edge of a processed

permanent magnet material preferentially by anode plate electropolishing with completely reverse plating. By making the amount of polishing equal to a part for the plating bed depth which adheres to the location concerned at the time of the plating of degree process The difference of the center section and edge of a plating bed depth which were formed after plating processing does not appear as variation of tolerance in a plating magnet front face, but does so the effectiveness that dimensional accuracy, such as whenever [parallelism / on the front face of a magnet /, flatness, and profile], is extremely excellent.

[0018] Moreover, in this invention, since the amount of polishing by electropolishing is correctly controllable, dimensional accuracy can be adjusted to altitude, further, acid-washing processing of degree process can be considered as an abbreviation or slight processing, and it also becomes possible to aim at compaction of process saving and the processing time etc.

[0019] In this invention, as a processed permanent magnet, the sintered magnet of which a well-known presentation and a bond magnet can also be made into an object, even if magnet configurations are also which configurations, such as the shape of a rectangular parallelepiped, a cube, cylindrical, and a ring, it is the same, and a corrosion-resistant protective coating does remarkable effectiveness so to an indispensable R-Fe-B system permanent magnet especially.

[0020] In this invention, in order that electropolishing liquid may control the amount of polishing by the resistance welding time etc., it needs only at immersion to be the with a pH of 6.0 or more neutrality or alkalinity in which a magnet is not dissolved, and that [its] in which the salts contained in liquid do not dissolve the processed permanent magnet at the time of immersion as much as possible further, either is desirable.

[0021] In the case of a R-Fe-B system permanent magnet, especially as electropolishing liquid, it consists of with a pH of 6.0 or more neutrality or alkalinity, and what has the presentation which contains EDTA (ethylene-diamine-tetraacetic acid), a pyrophosphoric acid, etc. as a complexing agent, and contains the lauryl sulfuric acid Na, alkylbenzene-sulfonic-acid Na, etc. as a surface active agent is desirable [a sodium sulfate, a sodium chloride, potassium sulfate, potassium chloride, etc.] as electric conduction salts as aforementioned.

[0022] Moreover, although the conditions of anode plate electropolishing change with classes of the electropolishing liquid to be used or permanent magnet In order to control the amount of polishing by the resistance welding time especially in the case of a R-Fe-B system permanent magnet As a processing tub, as an electrode vinyl chloride, a rubber lining, PP tub, etc. It is desirable to carry out on condition that 20-50 degrees C of solution temperature, current density 0.1 - 10 A/dm2, and electrical conductivity 100 - 300 mS/cm using insoluble anodes, such as stainless steel, etc. They are 30-40 degrees C of solution temperature, current density 1 - 5 A/dm2, and electrical conductivity 150 - 200 mS/cm still more preferably.

[0023] Although anode plate electrolytic polishing is carried out and the magnet material is electroplated after acid-washing processing in drawing 1 A which shows an example of the process of this invention, continuation Rhine processing is possible for acid-washing down stream processing from anode plate electropolishing to plating processing, without passing by machining like barrel finishing along another Rhine, since it can consider as an abbreviation or slight processing, and activation etc. can also be added suitably if needed and it is immersed in a processing tub in any case.

[0024]

[Example] The R-Fe-B system sintered magnet of a rectangular parallelepiped with which example 1 dimension consists of 30mmx15mmx2mm is used as processed magnet material 1. A sodium sulfate, electropolishing liquid with a temperature of 40 degrees C which contains EDTA as a principal component (trade name PAKUNA) When it was immersed in the YUKEN INDUSTRY CO., LTD. make and pH=7.0, it energized for 15 minutes by current density 1.0 A/dm2 and anode plate electropolishing processing was performed, magnet material 1a to which 2 micrometers was carried out for the center section in 12-micrometer depth, and electropolishing of the surface was carried out for the edge was obtained.

[0025] In this magnet material 1a, when nickel was covered with electroplating after backwashing by water, in the center section of magnet material 1a, nickel plating layer 2 of 25-micrometer thickness was formed in 15 micrometers and an edge, and the crossover of the flatness of a center section and

an edge was 0 micrometer.
[0026] When barrel finishing was performed to the same processed magnet material 1 as example of comparison 1 example 1 for 4 hours, magnet material 1b by which the center section was polished by 10 micrometers and the edge was polished in 20-micrometer depth was obtained. When short-time acid-washing processing was performed to this magnet material 1b and electroplating subsequently covered nickel on an example 1 and these conditions, in the center section of magnet material 1c, nickel plating layer 2 of 25-micrometer thickness was formed in 15 micrometers and an edge, and the crossover of the flatness of a center section and an edge was 0 micrometer.
[0027] When acid-washing processing of the same processed magnet material 1 as example of comparison 2 example 1 was carried out, 10 micrometers of surfaces were etched and electroplating covered nickel on an example 1 and these conditions to this magnet material 1c, nickel plating layer 2 of 25-micrometer thickness was formed in 15 micrometers and an edge, and 10 micrometers of nickel plating layers of an edge were thickly formed by the center section of magnet material 1c from the center section.
[0028] Since according to the approach of electroplating the crossover with a center section and an edge is 0 micrometer, and the outstanding flatness is obtained and only an edge can be preferentially polished after giving anode plate electropolishing by this invention so that clearly from an example 1, it turns out that the amount of polishing of a center section is small (2 micrometers) very much.
[0029] On the other hand, according to the approach (example 1 of a comparison) of electroplating, after performing barrel finishing, although excelled like the example of this invention, since not only an edge but a center section is polished while a barrel-finishing process takes much time amount, as for flatness, it turns out that the loss accompanying polishing is large. Furthermore, according to the approach (example 2 of a comparison) which does not polish an edge beforehand, it turns out that the dog bone phenomenon formed more thickly [an edge] than a center section has arisen.
[0030] By using the R-Fe-B system sintered magnet of the shape of a flat ring which consists of example 2 outer diameter of 40mm, a bore of 20mm, and thickness of 1mm as processed magnet material, the processed magnet material was immersed into this electropolishing liquid with a temperature of 20 degrees C using the same electropolishing liquid as an example 1, it energized for 20 minutes by current density 0.6 A/dm2, and anode plate electropolishing processing was performed. In addition, the electrical conductivity at the time of polishing was 250 mS/cm.
[0031] As for the obtained magnet material, electropolishing of the surface was carried out [the ring peripheral face center section] for 1 micrometer and a ring peripheral face edge in 15-micrometer depth. Subsequently, in this magnet material, when nickel was covered with electroplating after backwashing by water, in the ring peripheral face center section, nickel plating layer 2 of 29-micrometer thickness was formed in 15 micrometers and a ring peripheral face edge, and the crossover of the flatness of a center section and an edge was 0 micrometer.
[0032] By using the R-Fe-B system bond magnet of the shape of a cylinder which consists of example 3 outer diameter of 20mm, a bore of 17mm, and thickness of 30mm as processed magnet material, the processed magnet material was immersed into this electropolishing liquid with a temperature of 40 degrees C using the same electropolishing liquid as an example 1, it energized for 5 minutes by current density 2.0 A/dm2, and anode plate electropolishing processing was performed. In addition, the electrical conductivity at the time of polishing was 150 mS/cm. As for the obtained magnet material, electropolishing of 0.5 micrometers and the ring peripheral face edge was carried out for the ring peripheral face center section in 10.5-micrometer depth.
[0033] Subsequently, in this magnet material, when electroplating covered nickel on the same conditions as an example 3 after hole processing, in the ring peripheral face center section, nickel plating layer 2 of 21-micrometer thickness was formed in 11 micrometers and a ring peripheral face edge, and the crossover of the flatness of a center section and an edge was 0 micrometer.
[0034] It turns out that the effectiveness that the configuration is the same at any cases is acquired possible [obtaining a sintered magnet, bond magnet ******, and the outstanding flatness] so that clearly from an example 1 - an example 3. In addition, in the above-mentioned example, although the R-Fe-B system permanent magnet was taken up as a desirable operation gestalt, if it is the permanent magnet ingredient which can perform electroplating, it is possible to acquire the same effectiveness as the above.

[0035] Except energizing for 20 minutes by example 4 current-density 1.5 A/dm2, it is the same magnet material as an example 1, and the same approach, and anode plate electropolishing processing and nickel plating were performed. Distribution of each thickness dimension after anode plate electropolishing processing and nickel plating is shown in drawing 2 at the time of a magnet material. As a comparison, distribution of each thickness dimension after acid-washing processing and nickel plating is shown in drawing 3 at the time of the magnet material in the example 2 of a comparison. In addition, an axis of ordinate shows a distribution rate (%).
[0036] According to this invention, in the distribution after electropolishing, a center section and an edge are divided completely and form two crests so that clearly from drawing 2 . This shows that only the edge was polished by electropolishing. Moreover, the distribution after nickel plating has lapped mostly and understands that flatness is good for a center section and an edge.
[0037] On the other hand, although the distribution after acid-washing processing has lapped mostly in the approach of the example of a comparison shown in drawing 3 of not performing anode plate electropolishing processing in the center section and the edge, a center section and an edge are divided completely and the distribution after nickel plating forms two crests. This has proved that the thickness of an edge became thick according to the dog bone phenomenon.
[0038] Whenever [flatness / of the R-Fe-B system sintered magnet which has nickel plating layer obtained in the example 5 example 4 /, parallelism, and profile] was measured. The measurement result of flatness and parallelism is shown in drawing 4 , and the measurement result of whenever [profile] is shown in drawing 5 . In addition, the example which carried out energization processing for 30 minutes by current density 1.0 A/dm2 is doubled with the R-Fe-B system sintered magnet which has as a comparison nickel plating layer obtained in the example 2 of a comparison, and a list as reference, and it is shown in drawing 4 and drawing 5 . Whenever [profile] measured using the figure gage.
[0039] Although the profile after a material and nickel plating changes somewhat in the example of a comparison also about also whenever [profile / which flatness and parallelism show a good value compared with the example of a comparison which does not perform electropolishing processing, and shows them to drawing 5] so that clearly from drawing 4 , according to this invention, it turns out that the profile after a material and nickel plating hardly changes.
[0040] Drawing 5 is a graph which shows whenever [profile / of the permanent magnet obtained by this invention **** plating approach], and, in the case of the example of a comparison in which A does not have electropolishing, in after B ********** (current density 1.0 A/dm2), C is a case after electropolishing (current density 1.5 A/dm2). In all, the standard tolerance at the time of a material shows the case after electropolishing and nickel plating for change of the profile of a less than (it displays by 0.6mm) **0.3mm front face.
[0041] After having immersed this magnet material into electropolishing liquid with a same temperature [as an example 1] of 40 degrees C by having used the R-Fe-B system sintered magnet which consists of a 30mmx15 mmxHmm (H is 6.5mm, 4.0mm, and 2.8mm) dimension as processed magnet material, energizing for 10 - 30 minutes by current density 1.0 A/dm2 and performing electropolishing processing, magnetic properties (coercive force) were measured about the R-Fe-B system sintered magnet which covered nickel with electroplating. The result is shown in drawing 6 . Moreover, the corrosion-resistant (PCT) trial was measured about what performed electropolishing processing for 30 minutes. The result is shown in drawing 7 .
[0042] The permanent magnet obtained by this invention has magnetic properties good irrespective of the thickness of a magnet material, and the electropolishing processing time, and electropolishing processing also shows that corrosion resistance does not deteriorate so that clearly from drawing 7 , so that clearly from drawing 6 .
[0043]
[Effect of the Invention] Since a magnet edge can be preferentially polished by anode plate electropolishing according to this invention so that clearly from an example, The difference (dog bone phenomenon) of the center section and edge of a plating bed depth which were formed after plating processing It does not appear as variation of tolerance in a plating magnet front face, but permanent magnets, such as a R-Fe-B system magnet in which the plating layer which has the corrosion resistance which excelled and was excellent in dimensional accuracy, such as whenever

[parallelism, flatness, and profile], was formed, are offered stably, and the thing of them can be carried out.
[0044] Moreover, since this invention approach can control correctly the amount of polishing by anode plate electropolishing by current density, the resistance welding time, etc., it can adjust the dimensional accuracy of the permanent magnet after electroplating to altitude. Furthermore, while it is possible to carry out continuously in the same Rhine which put the processing tub in order for the anode plate electropolishing process and the electroplating process, and also being able to consider acid-washing processing after anode plate electropolishing processing as an abbreviation or slight processing and being able to aim at improvement in the production capacity by consecutive processing in process saving and the compaction list of the processing time, mass production method becomes possible.

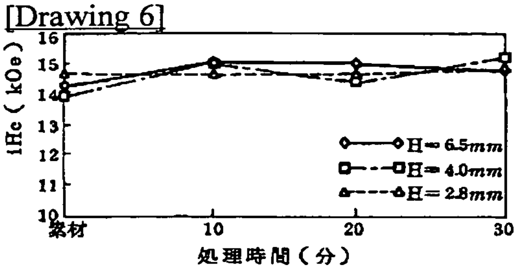
[Translation done.]

* NOTICES *

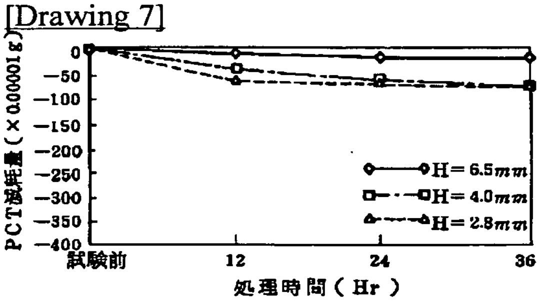
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

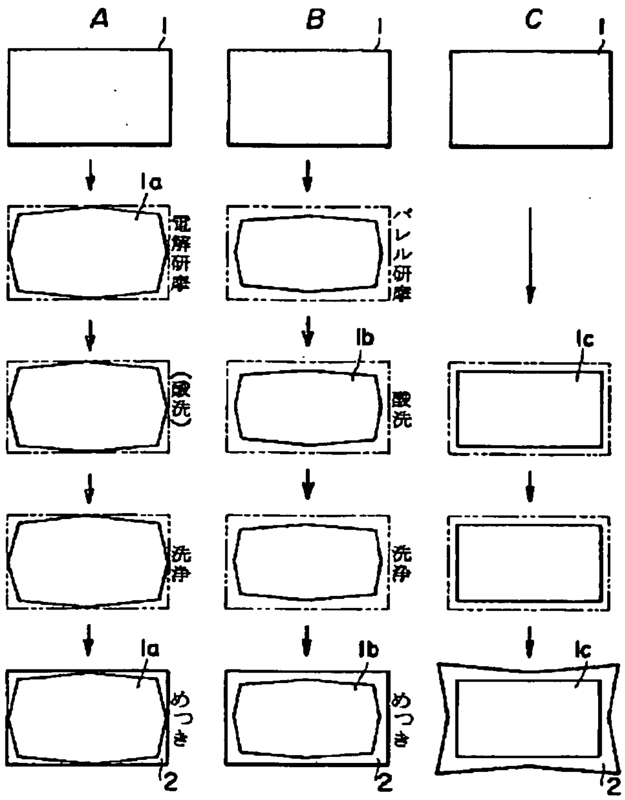
[Drawing 6]



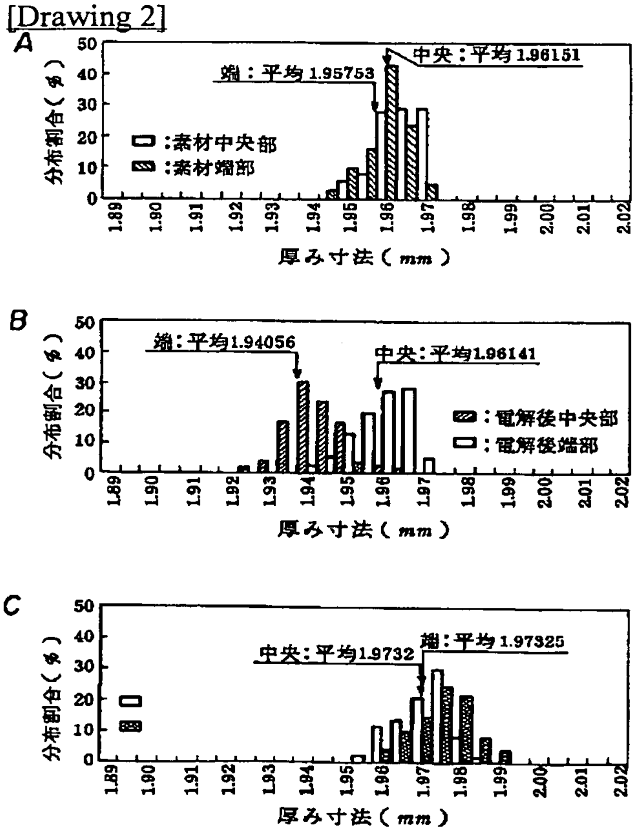
[Drawing 7]



[Drawing 1]

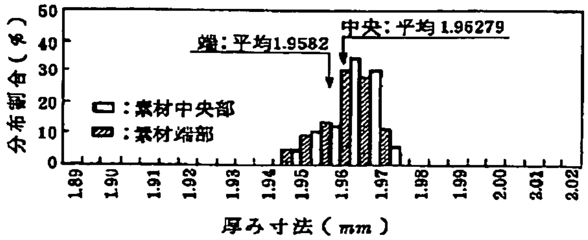


[Drawing 2]



[Drawing 3]

A



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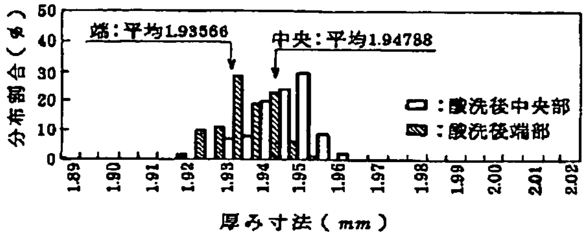

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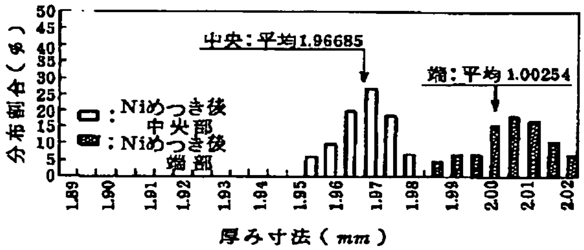
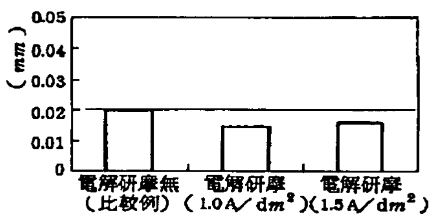


[Drawing 4]

A



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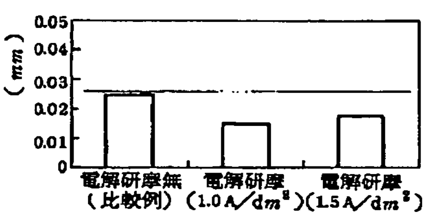
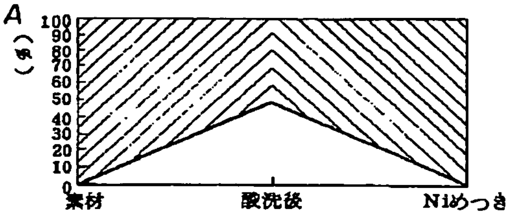


[Drawing 5]

A



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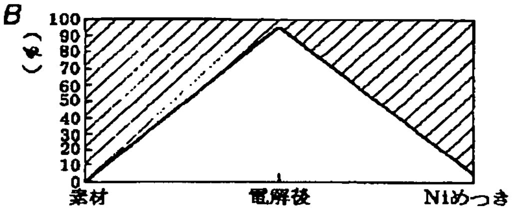

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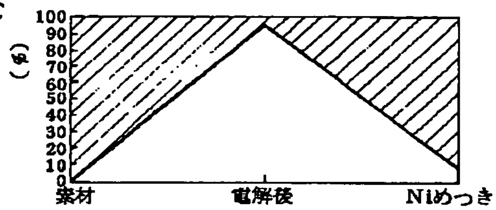

[Translation done.]